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Research Note

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DO CONTOUR TRENCHES REDUCE WET-MANTLE FLOOD PEAKS?

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ABSTRACT

A description is given of the January-February flood and associated events that took place on the east side of the Sierra Nevada in 1963, especially those occurrences recorded and observed in a small watershed in the flood-source area. Some 110 lineal miles of contour trenches in this 16-square-mile watershed may have reduced flow during that flood by about 60 acre-feet.

Winter floods along the Sierra Nevada and other far western mountain ranges result from prolonged, low-intensity rainfall. If rain falls on a shallow snowpack--as it often does--the resultant melt contributes to the runoff. If it falls on frozen soil, which may be impervious, the overland flow can be substantial. Winter floods from mountain watersheds are not a new nor an unusual phenomenon; however, the amount of damage caused by them has increased markedly with the urbanization of many floodplains A colorful account of the nature and magnitude of an early flood in the Sierra Nevada was written by John Muir in 1875.[2] Recently, Young and Harris[3] described the flood that originated from these mountains in 1963 and compared it to two that took place in 1950 and 1955.

To measure conditions associated with flooding on the east side of the Sierra Nevada range, a network of climatologic and streamflow instrumentation has been maintained in the Dog Creek drainage of the Truckee River watershed since 1957. This Note is based on measurements from this network, on a sampling of the characteristics of the contour trenches in the Dog Creek drainage, and on observations made by the author before and during the 1963 flood.

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[1] Plant Ecologist, stationed in Logan, Utah, at the Forestry Sciences Laboratory, which is maintained in cooperation with Utah State University.

[2] John Muir. Flood-storm in the Sierra. The *Overland Monthly* Devoted to the Development of the Country 14(6): 489-496. 1875.

[3] L. E. Young and E. E. Harris. Floods of January-February 1963 in California and Nevada. U.S. Geological Survey Water-Supply Paper 1830-A, 472 pp., illus. 1966.

Table 1.--Precipitation pattern recorded at the climatic station in watershed 1 January 28 through February 1, 1963

Hours and date	Time period	Precipitation increment	Precipitation intensity
	Hours	Inches	Inches/hour
2130-2400 Jan. 28	2.5	0.04	0.016
0001-0400 Jan. 29	4.0	.02	.005
0400-1400	10.0	.0	.0
1400-2400	10.0	.54	.054
0001-1200 Jan. 30	12.0	.60	.050
1200-1500	3.0	.75	.250
1500-2200	7.0	1.64	.236
2200-2400	2.0	.06	.030
0001-1200 Jan. 31	12.0	1.29	.109
1200-2400	12.0	.98	.082
0001-0500 Feb. 1	5.0	.46	.092
0500-1900	14.0	.24	.017
2130 Jan. 28 - 1900 Feb. 1	93.5	6.62	.071

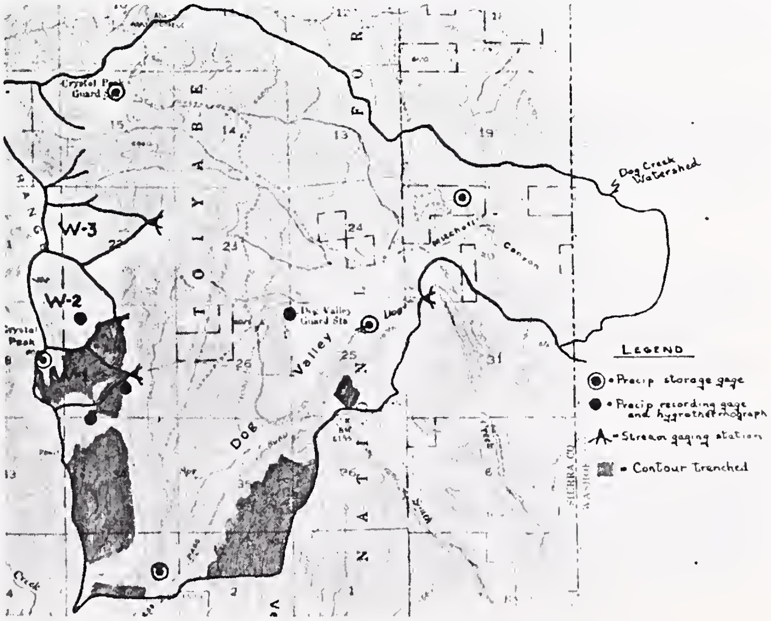

Figure 1.--Map showing Dog Creek watershed, three subwatersheds, instrumentation network, and contour-trenched areas.

THE 1963 WINTER FLOOD

The flood-producing precipitation that fell in and near the Sierra Nevada from January 29 to February 1, 1963, was associated with two warm frontal systems that moved inland from the Pacific. The storm lasted 4 days and set new precipitation maxima for periods greater than 24 hours. More than 20 inches of precipitation fell at many locations on the west side of the range, and 13.58 inches fell at one station, Mt. Rose, Nevada, on the east side.

The floods that resulted produced the greatest peak discharges from some watersheds in the history of recorded streamflow. This was the case at several gaging stations on the Truckee River and its tributaries. Storage in Lake Tahoe, Donner Lake, and Boca and Prosser Creek Reservoirs retarded much of the runoff; even so, about 20 square blocks of downtown Reno were inundated (see footnote 3).

The Dog Creek watershed, to which the remainder of this report is confined, is a part of the flood-source area of the Truckee River and is typical of much of the Truckee watershed. The Dog Creek watershed consists of 16.1 square miles upstream from the gaging station. It ranges in elevation from 5,700 feet at the stream gage to 8,500 feet at the highest peaks and has a modal elevation of 6,300 feet. Most of the acreage is forested with scattered, pole-size, second growth Jeffrey pine *(Pinus jeffreyi)*, large areas of which were killed in a 1960 fire. Good stands of Jeffrey pine, white fir *(Abies concolor)*, and associated species, that grow at higher elevations are interspersed with open areas, especially on south slopes and ridgetops. More than a square mile of the valley bottom is meadowland.

In 1962, heavy October rains soaked the soils in the Dog Creek watershed; so when cold air temperatures prevailed and snow cover was absent over most of the fall and winter, extensive soil freezing resulted, at least in the meadow areas of Dog Valley. Except in protected areas and on north-facing slopes above 7,000 feet, only a trace of snow remained on the ground prior to the late January storm. Over most of the watershed, moist soil and frost persisted beneath the surface few inches of dry soil. Streamflow was below normal for the midwinter period immediately preceding the flood; only 0.4 cubic foot per second (c.f.s.) was recorded at the Dog Creek gage, compared to a 5-year (1957-1961) January normal of 0.83 c.f.s.

The storm began in Dog Valley about 8 p.m. January 28. Before ending the evening of February 1 (table 1), it had deposited 8.28 inches of precipitation at the Dog Valley guard station and 6.62 inches in watersheds 1 and 2 (fig. 1). It is surmised from temperature records that precipitation began as snow, changed to rain January 29, then, near the end of the storm, turned to snow again at higher elevations.

Storm runoff was fed by water bleeding from a saturated mantle and from overland flow, probably an effect of the frozen soil. At the Dog Creek gaging station, this runoff peaked January 31 and again February 1 with mean hourly flows in excess of 700 c.f.s. (fig. 2). Streambanks along Dog Creek were extensively eroded and several erosion control dams in that stream damaged or destroyed (fig. 3).

There was substantive evidence that overland flow and channel cutting had produced some erosion at higher elevations, too. About 145 cubic yards of sediment was trapped behind the weir at the stream gaging station in watershed 1, and about 100 cubic yards in watershed 2. Unfortunately, the streamflow from these drainages was not satisfactorily recorded. The gaging stations did not operate because of ice on their stilling ponds and sedimentation about their inlet pipes.

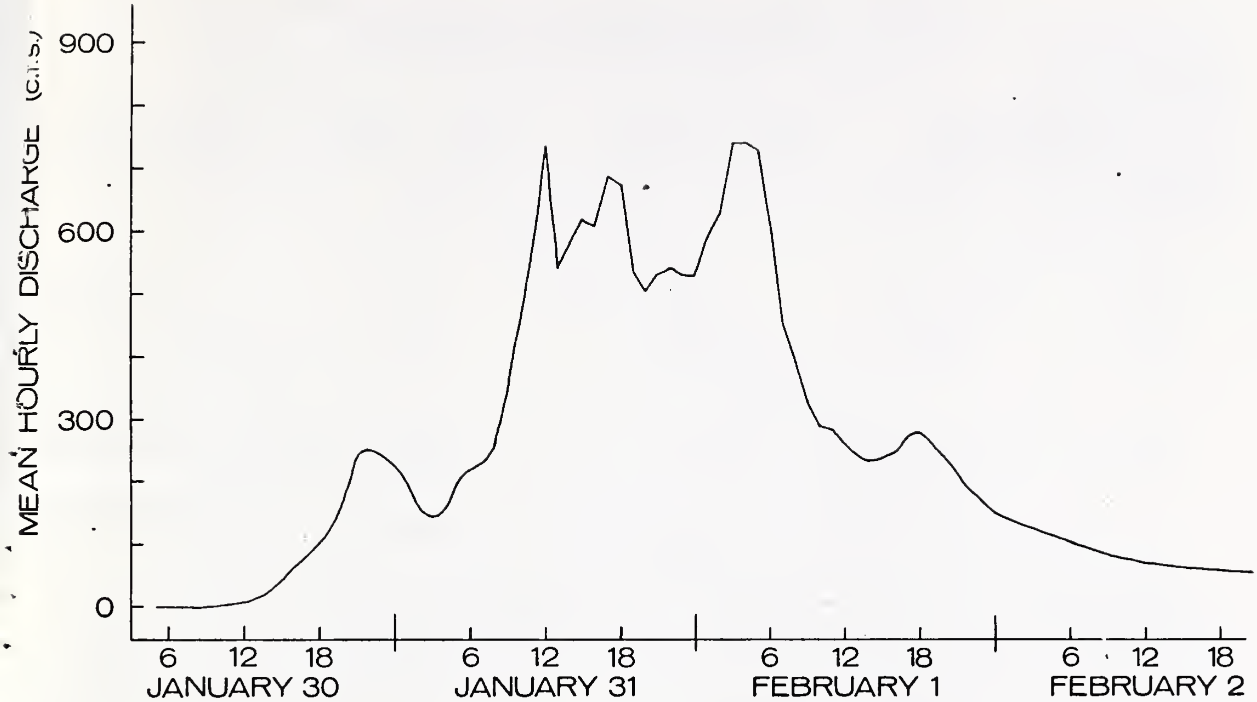

Figure 2.--Hydrograph for Dog Creek during 1963 flood.

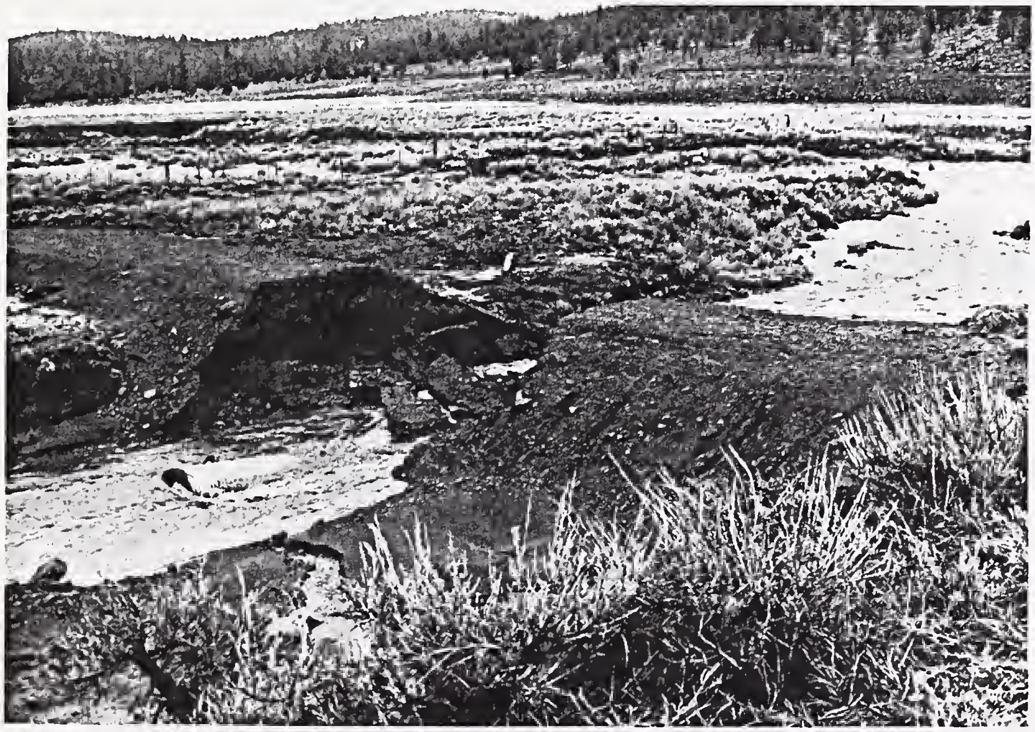

Figure 3.--A Dog Valley erosion control dam destroyed during 1963 winter flood. The flow shown here on February 1 was less than half that during the flood peak.

Table 2.--Length, size, and capacity of contour trenches in the Dog Creek watershed in 1963

Area description	Trench length	Average cross-sectional size	Total capacity	
	Miles	Sq. ft.	Cu. ft.	Acre-ft.
In and near watershed 1	13.50	9.29	662,191.2	15.20
South of watershed 1	34.24	8.70	1,572,848.6	36.11
Iron Mountain on the Verdi Range (NW slopes)	50.18	8.44	2,236,181.4	51.34
Miscellaneous small areas	12.61	5.0 (est.)	332,904.0	7.64
Total	110.53	--	4,804,125.2	110.29

THE CONTOUR TRENCHES

In August 1960 the Donner Ridge fire burned extensive areas in the southern half of the Dog Creek watershed. That autumn most of the burn was seeded with cereal rye, and the following year, steep portions were contour trenched, a practice commonly applied in the mountain watersheds of the West.[4] [5] Approximately, 110 lineal miles of contour trenches were constructed on denuded slopes having gradients of approximately 30 to 60 percent (fig. 1). The total capacity of the trenches in 1963 was 110.29 acre-feet (table 2).

During the 1963 flood-producing storm and for a short time thereafter, almost all trenches held some water. On pervious soils they held little; on most sites they were partially full (fig. 4); and in a few cases, they were full, some to overflowing. Although many trenches were full or almost so February 1, later surveys located few instances of eroded trench fill due to overtopping. Fortunately, the system was adequate to withstand the overland flow and seepage from a winter wet-mantle storm, although it was not designed for this purpose.

If all contour trenches in the Dog Creek watershed had been full at the same time, 110.29 acre-feet of water would have been detained on the slopes. This was not the case during the 1963 flood;so detention storage must be estimated at a lesser value. My observations February 1 indicated that actual detention storage was somewhere between 40 and 80 acre-feet. Upon visiting the valley several days later, I observed empty or almost empty trenches in most areas.

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[4] Reed W. Bailey and Otis L. Copeland. Vegetation and engineering structures in flood and erosion control. Paper presented at 13th Congr. Int. Union Forestry Res. Organs., Vienna, Austria, Sept. 10-17. 23 pp., illus. 1961.

[5] Edward L. Noble. Sediment reduction through watershed rehabilitation. Paper presented at the Federal Interagency Sedimentation Conf., Jackson, Miss. 29 pp., illus. Jan. 1963.

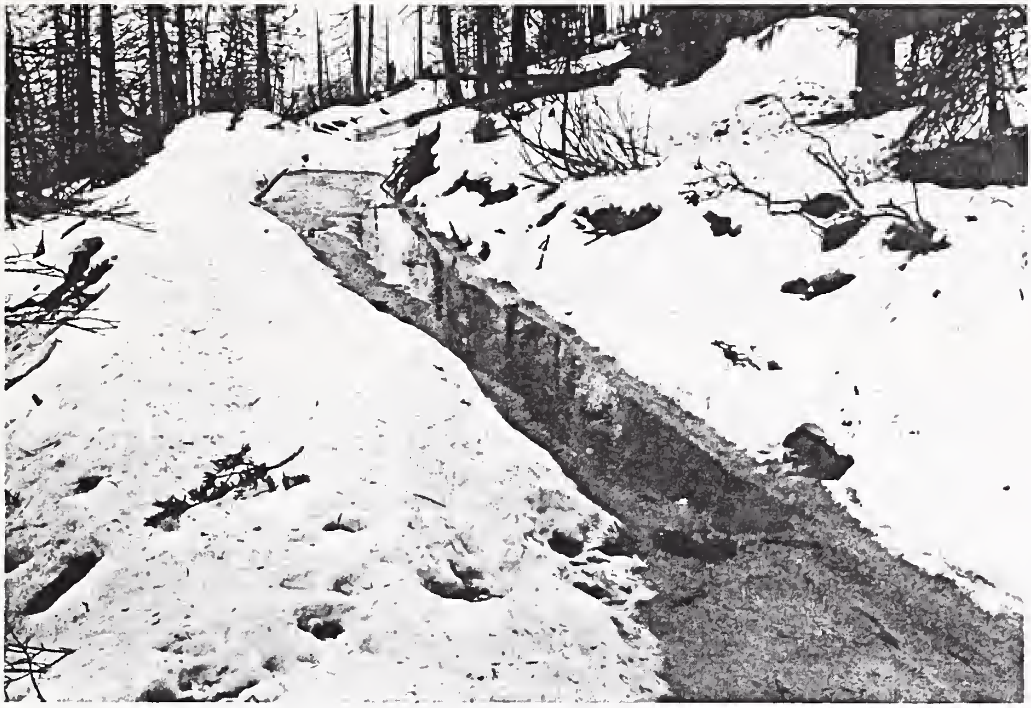

Figure 4.--Water from the 1963 flood-producing storm trapped in a portion of one contour trench in the Dog Creek watershed. Detention storage of this type should reduce flooding downstream.

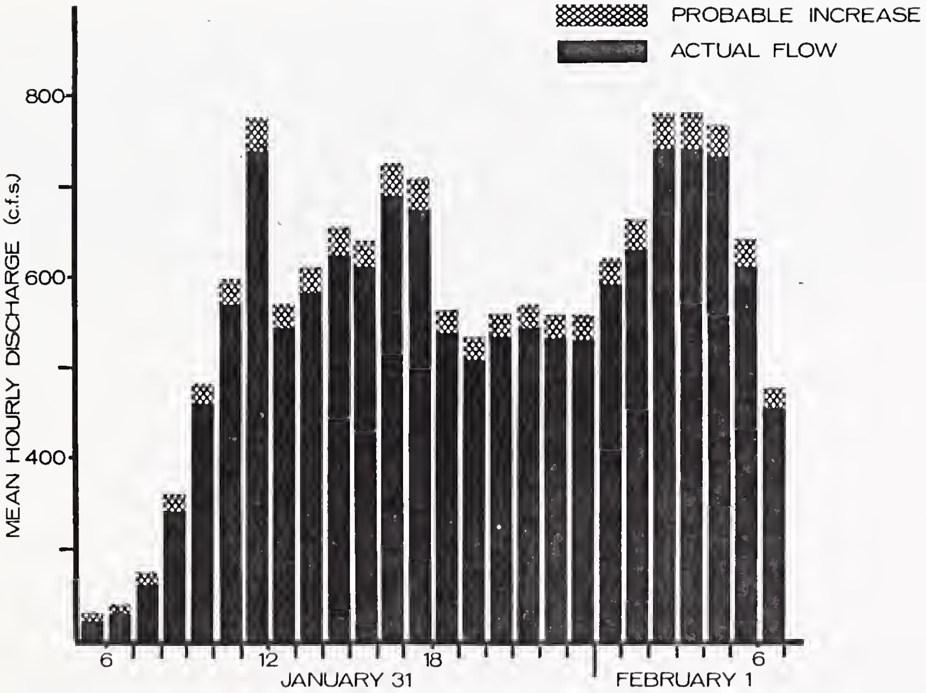

Figure 5.--Probable increased peak discharge from Dog Creek if the contour trench system had not existed in the watershed.

For the purpose of illustrating the hypothesis that the contour trenches affected the flood peak on Dog Creek, let's assume that 60 acre-feet of water was detained in the contour trenches during the peak flow past the Dog Creek gaging station. If those 60 acre-feet had been contributed to the main stem of Dog Creek at the same time as runoff from the remainder of the watershed reached its peak, the hydrograph would have had a different shape and a higher maximum flow. That hypothetical hydrograph is superimposed on the actual hydrograph (fig. 5) to show the amount of storm runoff that might be expected without contour trenching. The peak flow is shown to be higher. The recession flow would probably be more rapid without trenches, too, because overland flow would at least partially replace the temporary storage of water in the trenches and in the soil under them.

If the maximum flow from most Truckee tributaries had been reduced proportionately through contour trenching, the Truckee flood would have been less destructive. After the 1950 and 1955 wet-mantle floods, observers speculated about the effects of depression storage and snowpack characteristics on the timing and volume of runoff generated by rain and melting snow. Some were of the opinion that a slight reduction in the peak flow, at least on the Truckee River, would have resulted in far less damage. Although large reservoirs serve best for wet-mantle flood control, watershed treatments that provide additional depression storage and more tortuous routes for runoff also might reduce maximum flows the necessary few percent. Contour trenches may be the best means of accomplishing this, at least on burned or denuded slopes. This possibility deserves further study. It is a conceivable benefit that might be considered when watershed treatment is contemplated.

CONCLUSIONS

The nature of these observations and data does not permit a rigorous analysis of the effects of contour trenches on wet-mantle winter floods; nevertheless, some reduction in flooding is indicated. Contour trenches were intended originally to control the overland flow caused by intense summer rains falling on a dry mantle and--when adequately designed and properly installed--they serve this purpose admirably. They will not prevent floods caused by long-lasting, low-intensity rains falling on a frozen or a saturated mantle. However, regardless of conditions, streamflow will be affected if runoff water is held in the trenches for several hours. Trenches cannot prevent floods like the Sierra Nevada flood of 1963, but they may reduce the peak flows of such floods to such an extent that damage will be minimized.

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